

- HEINROTH, O. (1908): Trächtigkeits- und Brutdauern. Zool. Beobachter 49, 14–25.
- JEANNIN, A. (1936): Les Mammifères sauvages du Cameroun. Paris: Lechevalier.
- JORDT, D. K. (1962): Diät zur Handaufzucht eines Zebrauckers. Int. Zoo Yearbook 4, 329.
- KETELHODT, H. F. VON (1973): Breeding Notes on Blue Duiker. Zool. Afr. 8, 138.
- (1977a): The Lambing Interval of the Blue Duiker (*Cephalophus monticola* Gray) in Captivity, with Observations on its Breeding and Care. South Afr. J. Wildl. Res. 7, 41–43.
- (1977b): The Composition of the Milk of the African Dwarf Goat, Springbok and Blue Duiker. Zool. Afr. 12, 232.
- KRUMBIEGEL, I. (1954): Biologie der Säugetiere, Bd. 1 u. 2. Krefeld: Agis Verlag.
- MENTIS, M. T. (1972): A review of some life history features of the large herbivores of Africa. Lemmergeyer 16, 1–89.
- NAAKTGEBOREN, C.; SLIJPER, E. J. (1970): Biologie der Geburt. Hamburg und Berlin: Paul Parey.
- RALLS, K. (1970): Duikers – From African Forests to “African Plains”. Animal Kingdom 73, 18–23.
- (1973): *Cephalophus maxwellii*. Mammalian Species 31, 1–4.
- RODE, P. (1943): Mammifères Ongulés de l’Afrique Noire II. Paris: Librairie Larousse.
- SCHWEERS, S. (1981): Fleischfressende Antilopen. Der Zoofreund 42, 17–19.
- TEMBROCK, G. (1972): Tierpsychologie. Neue Brehm-Bücherei 455, Wittenberg-Lutherstadt: A. Ziemsen Verlag.
- WALTHER, F. (1958): Zum Kampf- und Paarungsverhalten einiger Antilopen. Z. Tierpsychologie 15, 340–380.
- (1966): Mit Horn und Huf. Berlin und Hamburg: Paul Parey.
- (1968): Ducker, Böckchen und Waldböcke. Grzimeks Tierleben, Säugetiere 4, 316–337. München: Kindler.
- WHITTLE, E. C.; WHITTLE, F. P. (1977): Domestication and breeding of Maxwell’s duiker. Niger. Fld. 42, 13–21.
- ZALOMIS, E. A.; CROSS, R. (1974): A Field Guide to the Antelopes of Southern Africa. Natal Branch, Wildl. Soc. South Afr.

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Aspects of reproductive behaviour of Bharal (*Pseudois nayaur*) in Nepal

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Abstract

Portions of bharal breeding and lambing seasons were observed in west-central Nepal. Mixed herds aggregated for the rut, but males did not segregate from females after breeding season. Activity patterns indicated 2 diurnal peaks, activity may have been affected by temperature. Behavioural repertoires did not differ between populations, but rates of some displays did. Lambing season was later than a more northern population, probably due to climatic conditions. Mother-young behaviour compared closely with North American sheep. Observations confirmed the gestation period as approximately 160 days.

Introduction

Knowledge of bharal (*Pseudois nayaur*) reproductive behaviour is limited to a study of a population during the rut in north-central Nepal (see SCHALLER 1977). Information on ecology and natural history has been presented from studies of 3 bharal populations in

Nepal (SCHALLER 1973, 1977; WEGGE 1979; WILSON 1981). Information is lacking on parturition and mother-young behaviour. In addition, a reported gestation period of 160 days (CRANDALL 1964) has not been verified by field observations.

A study of bharal reproductive behaviour was conducted in Nepal during the 1976–1977 breeding and lambing seasons. The goals of this paper are: 1. to present data on herd dynamics during the breeding season, 2. to present data on seasonal activity patterns, 3. to compare behavioural repertoires of 2 bharal populations, 4. to define the season of birth, and 5. to describe mother-young behaviour.

Study areas and methods

Descriptions of bharal sex and age classes have been presented by WILSON (1981).

Portions of the breeding and lambing seasons were observed in the Dhorpatan Shikar Reserve (82°50'–83°15' E, 28°30'–50' N) of west-central Nepal (see WILSON 1981). Courtship and aggressive behaviour were observed in the Sun Dah block with the majority of the observations recorded in the headwaters of Chhapka Khola (WILSON 1981). An estimated 105–110 bharal were reported in the block (WILSON 1977), with 50–60 in the 500 ha headwaters area (4000–4900 m altitude). Agonistic and courtship encounters were recorded on data cards, and herd activity counts were recorded every 15 minutes. Herd composition counts were recorded at the beginning of the day and at any time herd composition changed.

Parturition was observed in the headwaters areas of Gur Gad and Bakre Kholas in the Barse block (WILSON 1981). Approximately 110–120 bharal were estimated to frequent the headwaters areas and south-facing slopes of Barse ridge (WILSON 1977). The area had been under heavy legal and illegal hunting pressure from 1970 to 1976. Two to 4 Class III males were harvested by trophy hunters each year for 7 consecutive years. In addition, domestic grazing was extremely heavy in June, July, and August, as 15,000 to 16,000 domestic sheep moved into the Phagune and Barse blocks each year. In comparison, the Sun Dah area was more remote and not subject to such heavy hunting and grazing pressures.

Onset of parturition was determined by recording the number of new-born lambs and yearling lambs in daily herd composition counts. Observations and herd composition counts determined isolation of ewes prior to parturition and selection of lambing habitat. Suckling behaviour was quantified by recording initiation, duration, and termination of suckling bouts.

Results and discussion

Herd dynamics

There are several population (Table 1) and habitat differences between the Dhorpatan study areas and the Lapche and Shey study areas of SCHALLER (1977). At similar altitudes, Shey hillsides consisted of more bare ground (63 %) and less grass (21 %) than Lapche (43 % ground and 28 % grass) or Dhorpatan (29 % ground and 58 % grass) (SCHALLER 1977; WILSON 1981). The largest mixed herd observed during the rut was 49 bharal. A mean mixed herd size of 25 bharal suggested aggregation of herds for breeding (Table 2). During the rut at Shey, mean herd size was 18 bharal with a maximum of 61 animals (SCHALLER 1977). In Dhorpatan, 85 to 90 % of Class I–III males were in mixed herds prior to the main rut (Table 2), whereas SCHALLER (1977) reported only 33 % for the Shey population. Male groups were infrequently observed in the Dhorpatan area; 9 groups in autumn and only 1 in spring. Some males wandered during the December rut, but solitary males or small groups of males accounted for a small portion of all observed males (Table 2). In comparison, SCHALLER (1977) reported that solo males were fairly common during the height of the rut.

Male bighorn sheep (*Ovis canadensis*) segregate spatially from females and by habitat selection to minimize competition against mothers of their offspring (GEIST and PETOZ 1977). WEGGE (1979) reported that there was no evidence of bharal males forming distinct bands or occupying separate habitats. The higher percentage of grass coverage on Dhorpa-

Table 1

Herd composition data (in %) of four bharal populations in Nepal

Location (source)	Classes of Males ^a					♀♀	lamb	Yrlg	Total # classified	lambs 100 ♀♀	Adult ♂♂ 100 ♀♀	Yrlg ♂♂ 100 ♀♀
	V	IV	III	II	I							
Shey (SCHALLER 1977)	8.2	9.0	5.7	2.5	4.1	43.4	17.2	9.8	122	40	68	8
Sun Dah (WILSON 1981)	III	II		I		26.3	20.5	20.7	803	78	123	40
Lapche (SCHALLER 1973)	IV	III	II	I		25.9	22.7	21.3	216	88	116	43
Barse (WILSON 1981)	III	II		I		33.2	25.5	26.7	639	77	44	40

^a = differences in age classes previously discussed by WILSON (1981)

Table 2

Percent of bharal males (Classes I–III) seen alone, in male groups (MG), and in mixed groups (MxG), in comparison to the number of mixed groups and female groups observed in the Dhorpatan Shikar Reserve (1976–1977)

Month	# Males	% Alone	% in MG	# MG	Mean MG size ± SE ^a	% Males in MxG	# MxG	Mean MxG size ± SE	# Female groups
Oct	123	1	9	3	3.7 ± 1.0	90	38	11.0 ± 1.1	20
Nov	98	3	12	2	6.0 ± 1.4	85	29	10.0 ± 1.1	11
Dec	299	1	6	4	4.8 ± 1.4	93	36	24.6 ± 2.3	2

^a = Standard error of the mean

tan slopes suggests less competition for available forage, thus negating segregation of the sexes. Similarly, 83 % of the Lapche bands were mixed herds during March (SCHALLER 1977). Segregation of male and female bighorn sheep held true regardless of snow depth (GEIST and PETOCZ 1977), suggesting snowfall may not affect bharal social organization, whereas food or other habitat characteristics may.

Activity patterns

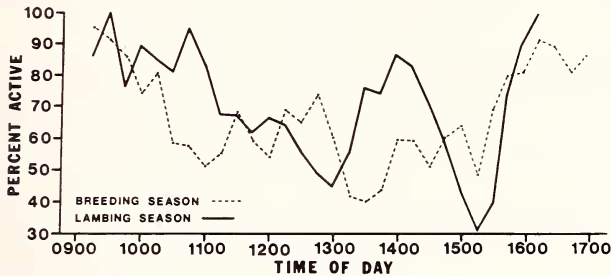
Activity of Dhorpatan bharal showed 2 diurnal peaks (see Fig.). During the December rut, bharal were least active during the heat of the day (1330–1500 hr), but activity increased as late afternoon temperatures dropped (Fig). At Shey, however, more bharal were active during the afternoon hours (SCHALLER 1977).

In May and June, diurnal peaks were observed later in the afternoon (Fig.). March temperatures and bharal activity at Lapche (SCHALLER 1977) were similar to December

temperatures (WILSON 1981) and bharal activity in Dhorpatan. Hence, warmer temperatures, as well as emergent grasses may have affected bharal activity during the lambing season.

Behavioural repertoires

Direct and indirect aggression were observed as described by SCHALLER (1977). In addition, I observed 2 previously unreported forms of aggression: hornpull and neck-fight. The horn-pull was observed 3 times between interacting Class III males, whereas the neck-fight was observed only once. SCHALLER (1977) reported, but did not quantify, the broadside display, which included a somewhat lowered neck. I observed a single broadside



Seasonal activity patterns (number of 15 min herd activity counts: Breeding - 220, Lambing - 170)

display by a Class III male who twisted his horns toward a Class III opponent. The horn-pull, neck-fight, and broadside display seem to have been rare behaviour patterns in this population.

I observed 128 agonistic encounters between 1 and 15 December 1976. The initiating display was predominately a mount (23 % of the encounters), clash (21 %), or low-stretch (18 %). Initiators also lunged (9 %), jumped (9 %), jerked (5 %), or butted (5 %), whereas rare patterns accounted for the remaining 10 % of the encounters. The majority of agonistic encounters (53 %) were between Class III males, whereas 21 % were Class III males interacting with Class II males. Male bharal, markhor (*Capra falconeri*), and tahr (*Hemitragus jemlahicus*) interact mainly with members of their own age class or the next smaller or larger class (SCHALLER 1977). NIEVERGELT (1974) reported similar patterns of behaviour for *C. ibex*.

Courtship encounters were enumerated between 1 and 17 December 1976. Male bharal courted females with behaviour patterns as previously described by SCHALLER (1977). Differences existed between Shey and Dhorpatan populations in the displays used by males that induced females to squat and urinate. In Dhorpatan, males commonly approached females in the low-stretch and sniffed their vulva (76 % of 137 encounters). Females also urinated when males displayed the low-stretch with kick or chin-on-rump (22 %), and occasionally urinated when mounted by males. At Shey, females were induced to urinate by sniffing only (59 % of 265 encounters), by displaying and sniffing (25 %), by displaying only (11 %), following (3 %), or mounting (2 %). Shey males sniffed females twice as frequently as they lipcurled (SCHALLER 1977), whereas Dhorpatan males sniffed only 1.3 times more than they lipcurled.

Male bharal courted females with just 1 or 2 displays ($\bar{x} = 1.6$; 301 encounters), most frequently a low-stretch and sniff (59 %). SCHALLER (1977) reported similar findings for Shey bharal and concluded that the low-stretch was most prevalent in species that court crudely with 1 or 2 abrupt displays, as do bighorn sheep (GEIST 1971). Copulations were observed on rock ledges where only one male could accompany a female. Female mountain

sheep (GEIST 1971) and female bharal (SCHALLER 1977) move onto rock ledges to avoid courting males.

The prerut for the Shey population was 2 to 28 November 1973 with the main rut commencing on 29 November, and an estimated peak in mid-December. Onset of the main rut was determined by significant increases in the number of courtship encounters per observation hour and mounting of estrous ewes (SCHALLER 1977). A similar interaction rate indicated the Dhorpatan main rut commenced between 12 and 15 December (Table 3), and copulations were first observed on 15 December. As the rut intensified, females responded to increased courting by squatting and urinating more frequently, instead of departing or not responding to male displays. Male behaviour changed from no response to more lipcurls as females urinated more to appease courting males (Table 3).

Table 3

Male and female responses (in %) during 301 courtship encounters between 1–17 December 1976
(number of encounters in parentheses)

Behaviour	1–5 Dec (29)	7–11 Dec. (104)	12–17 Dec. (168)
Female			
None	34	23	18
Squat/Urinate	14	36	56
Depart	38	38	22
Aggressive	14	3	2
Copulation	0	0	2
Male			
None	34	63	27
Flehmen	24	31	60
Attempted Mount	31	1	7
Chase	11	5	4
Copulation	0	0	2
# encounter/hr	2.23	7.30	8.50

Class I and II males occasionally courted females in early December (usually with attempted mounts or chases), but females rarely responded, except to depart or react aggressively (Table 3). An analysis of daily rates of interaction for Class II and III males (using total male-hrs of observation to adjust for skewed male class composition) indicated no significant class differences in courtship rates ($F = 0.72$; d. f. = 1,26; $P > 0.25$). However, significant class differences ($F = 5.28$; d. f. = 1,26; $P < 0.05$) in rates of agonistic encounters indicated that Class III males were more aggressive as females came into estrous in mid-December. At Shey, younger male bharal were more active in the prerut, whereas adult males became more active during the week prior to the onset of the main rut (SCHALLER 1977).

Season of birth

New born lambs were first observed on 27 May 1977. Only 23 % of the adult females had new-born lambs at heel by 10 June, which indicated (from FROST 1942) a peak in parturition between 13 and 18 June. In 1975, the first new-born lamb was observed on 5 June and lambing on 12 June (WEGGE 1976). In northern latitudes and high mountains, lambing season of North American sheep is later and more closely synchronized than elsewhere (GEIST 1971; BUNNELL 1982). However, the season of birth for the high altitude bharal (4100–4500 m in June; WILSON 1981) seems to be longer (approx. 45 days),

comparing more closely to the southern British Columbia bighorn (BLOOD 1963). Also, the lambing season of the Dhorpatan population was approximately 2 weeks later than that projected for the Shey population, probably due to more snowstorms in late May and early June (WILSON 1981). Similar observations have been reported for bighorn sheep in Montana (STEWART 1982) and for all sheep (*O. dalli*) in Alaska (NICHOLS 1978).

Herd composition counts on 22 May indicated skewed numbers of yearling-lambs per 100 ♀♀, suggesting a withdrawal of adult females 4 to 5 days prior to parturition. Bharal lambing habitat was broken rugged cliffs above grass-covered slopes or basins, as described for bighorn sheep (GEIST 1971). One female with a new-born lamb was observed in rocks at 4440 m, and a general movement to higher altitudes was reported for the month of June (WILSON 1981).

Mother-young behaviour

Twenty-eight complete suckling bouts were observed during 6 months of fieldwork; 7 prior to and during the rut, 21 during the lambing season. Mean duration of suckles may be inversely related with lamb age ($r = -0.72$; $F = 4.73$; $P > 0.10$). A 1-day-old lamb suckled 3 times ($\bar{X} = 140$ s; $SE = 2.6$) during 6.4 hrs of observation, and a 5 to 7-day-old lamb suckled 3 times averaging 81 s per suckle ($SE = 31$). Lambs estimated to be 1 to 2-weeks old suckled an average 33 s ($SE = 4.3$) in 15 bouts. In comparison, 7 suckling bouts observed in October, November, and December indicated that lambs 4 to 6-months-old suckled infrequently and for short durations ($\bar{X} = 10$ s; $SE = 1.6$).

Females initiated suckling bouts by nuzzling their new-born lambs, whereas lambs 1 to 2-weeks-old initiated suckles by approaching their dams. During autumn, lambs initiated suckling by running around the front of the female and diving under her side to reach the udder. This run-around behaviour is common to many ungulate species (see GEIST 1971). Bharal young suckled from the side and new-born lambs sometimes stood directly under the female. All attempts, but one, to suckle from the rear were rebuked. Similar positions were reported for bighorn lambs (GEIST 1971). In May and June, females terminated 18 of 21 suckles by either walking away (50 %) or stepping over the lamb. Bighorn females usually stepped over (59 %) and occasionally turned sharply away (18 %) or walked away from suckling lambs (GEIST 1971).

Conclusions

Gestation was estimated by subtracting the female isolation period (4–5 days) from 164 days between the first observed copulation and the first observed new-born lamb. The estimation (159–160 days) compared closely with previously reported estimates (CRANDALL 1964; SCHALLER 1977). The rut of the Dhorpatan population was estimated to have been from 15 December 1976 to 28 January 1977 and peaked at 4 to 9 January. This suggested a longer rut than previously reported and 2 weeks later than the Shey population. The 45-day lambing season commenced on 23 May and probably peaked between 13 and 18 June 1977. Later seasons of breeding and parturition suggested adaptation to climatic conditions peculiar to the study area. Available forage, spring “green-up”, and temperature may have affected bharal activity, as well as social organization of the Dhorpatan population. Differences in behavioural repertoires, frequencies of displays, and rates of interaction may be attributed to the behavioural scaling of each population (WILSON 1975).

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Zusammenfassung

Aspekte des Fortpflanzungsverhaltens des Bharal in Nepal

Zur Zeit der Reproduktion wurden Bharale in west-zentralen Regionen von Nepal beobachtet. Dabei hat sich ergeben, daß sich zur Brunstzeit gemischte Herden sammeln, und daß sich nach der Fortpflanzungszeit die männlichen Tiere nicht von den weiblichen Tieren trennen. Das Aktivitätsmuster zeigt im Tagesgang zwei Höhepunkte, wahrscheinlich von der Temperatur beeinflusst. Das Repertoire von Verhaltensweisen ist in den beiden beobachteten Herden zwar gleich, aber in der Häufigkeit mancher Imponierbewegungen ergeben sich Unterschiede. Die Setzzeiten für Lämmer liegen später als bei den nördlicheren Herden, wahrscheinlich unter klimatischem Einfluß. Das Verhalten zwischen Muttertier und Jungen ähnelt dem nordamerikanischer Schafe. Durch eigene Beobachtungen kann bestätigt werden, daß die Trächtigkeit ungefähr 160 Tage dauert.

References

- BLOOD, D. A. (1963): Some aspects of behaviour of a bighorn herd. *Can. Field-Nat.* 77, 79-94.
- BUNNELL, F. L. (1982): The lambing period of mountain sheep: synthesis, hypotheses, and tests. *Can. J. Zool.* 60, 1-14.
- CRANDALL, L. (1964): The management of wild mammals in captivity. Chicago: Univ. Chicago Press.
- GEIST, V. (1971): Mountain sheep. Chicago: Univ. Chicago Press.
- PETOCZ, R. G. (1977): Bighorn sheep in winter: do rams maximize reproductive fitness by spatial and habitat segregation from ewes? *Can. J. Zool.* 55, 1802-1810.
- NICHOLS, L. (1978): Dall sheep reproduction. *J. Wildl. Manage.* 42, 570-580.
- NIEVERGELT, B. (1974): A comparison of rutting behaviour and grouping in the Ethiopian and Alpine ibex. In: The behaviour of ungulates and its relation to management, ed. by V. GEIST and F. WALTHER, pp. 324-340. IUCN Publ. No. 24. Morges: IUCN.
- SCHALLER, G. B. (1973): On the behaviour of blue sheep (*Pseudois nayaur*). *J. Bombay Nat. Hist. Soc.* 69, 523-537.
- (1977): Mountain monarchs. Chicago: Univ. Chicago Press.
- STEWART, S. T. (1982): Late parturition in bighorn sheep. *J. Mammalogy* 63, 154-155.
- WEGGE, P. (1976): Himalayan shikar reserves. FAO NEP/72/002, Field Document No. 5, Kathmandu: Tribuvan Univ. Press.
- (1979): Aspects of the population ecology of blue sheep in Nepal. *J. Asian Ecol.* 1, 10-20.
- WILSON, E. O. (1975): Sociobiology. Cambridge: Belknap Press.
- WILSON, P. (1977): Blue sheep census. HMG, Nat. Parks and Wildl. Conserv., Kathmandu (Unpublished report).
- WILSON, P. (1981): Ecology and habitat utilisation of blue sheep *Pseudois nayaur* in Nepal. *Biol. Conserv.* 21, 55-74.

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